Chapter 1

Literature Review

1.1 Introduction

This chapter details the previous work done in and around the area of Fire Engineering by other academics and research staff. This section identifies the research gap that this research is intended to fill.

Fire engineering covers a broad aspect of research, from investigation into costs, materials, construction methods and the psychology of occupants during fires. This chapter covers the research done in these areas, though mainly in regards to construction and costs of fires. It also includes a brief literature review on the construction of a software tool as this was the predicted outcome of this research.

1.2 Fire Protection

Society dictates that people should be able to enjoy a reasonable level of safety during day to day activites and as such, part of this is protection from natural and man made phenomena such as fire. Such demands for safety, espcially after large incidents where a considerable loss of life or property occurred, led to the initial development of the fire building regulations (Stollard and Johnston, 1994). These building regulations developed over time into the current form we have today in the UK (Communities and Local Government, 2006). These regulations are in place so that the building can be designed safely to allow occupants to escape should a fire occur and to prevent excessively quick fire spread, again, allowing for escape. This focus on life safety is the main concern behind the current regulations and appears to have been reasonably successful, as fire deaths have declined steadily over the past decade (Department for Communities and Local Government, 2010). However, there has been a steady increase in the cost of fires over the same period (Association of British Insurers, 2009). These figures seem to show that whilst the building regulations seem to be working for reducing and keeping the number of fire deaths low, their doesn't seem to be any reduction to the cost of fires by constructing to meet the building regulations.

Whilst Approved Document B lays down the building regulations in relation to fire safety and details the easiest method of meeting these regulations, it is by no means the only method of meeting the regulations. Designers also have aceess to two British Standards that set out methods of meeting the regulations. These British Standards are more advanced methods of designing buildings and therefore are used in the larger and more complex buildings. These two codes are also more open in how the design of the building can attain fire safety certification. BS 9999: Code of Practice for Fire Safety in the Design Management and Use of Buildings (BSI, 2008) is a relatively new code that attempts to make it easier for designers to incorporate fire safety into more complex structures without having to use PD 7974: Application of Fire Safety Engineering Principles to the Design of Buildings (BSI, 2003) which is used in the most complex of buildings because it reduces fire safety to the first principles of fire science and requires an understanding of flame spread, fire dynamics and combustion science to use effectively.

To meet the fire regulations, buildings have to be protected by differenting fire protection systems. These systems delay the spread of fire and make it easier for the occupants to escape. The design of the building itself and the restriction in the use of combustible materials is one method of preventing fire spread is the main aspect behind the regulations. This method of preventing fire spread is refered to as passive fire protection, as the protection does not need to change state to complete it's function in preventing fire spread. However, additional systems are installed, such as fire alarms and extinction systems are installed and these are active fire protection measures. The combination of both active and passive measures provides the complete fire protection design for a building. Previous research has suggested that the includsion of active measures such as sprinklers can reduce the passive protection measures included in a building (Baldwin and Thomas, 1974) though it's still believed that both systems should be used complimentaryly (Haack, 2004).

1.3 Decision Support Systems

A Decision Support System (DSS) can be defined as a "computer based systems that help decision makers confront ill-structured problems through direct interaction with data and analysis models" (Sprague and Watson, 1993). These systems allow designers and managers to access help in the decision making process.

The majority of DSS tool have similar features in common. These are:-

- They are non routine and involve frequent *ad hoc* analysis, fast access to data and generation of non standard reports
- They often address What if? questions
- They have no obvious correct answer; a manager has to make qualitative trade offs and take into account situational factors

These features are discussed in Value Analysis: Justifying Decision Support Systems (Keen, 1981). This paper disucsses the fact that DSS tools are helpful in the role they play but are difficult to quantify in regards to cost savings. However, Keen describes that tools should be:-

1. Flexible
2. Easy to use
3. Responsive
4. Communicative

He explains that it should be flexible to handle different situations, easy to use so it can be put into different users workflow, responsive as it must not impose a structure on the user and be rapid in its calculations and communicative so that the end user can get the knowledge they need from the tool qucikly and easily. By following these four "rules", the tool should be of the most use to the end users.

In his book (Keen, 1980) , Keen describes the percieved benefits of a DSS system. These are:

1. Increase in the number of alternatives examined
2. Better understanding of the business
3. Fast response to unexpected situations
4. Ability to carry out *ad hoc* analysis
5. New insights and learning
6. Improved communication
7. Control
8. Cost savings
9. Better decisions
10. More effective teamwork
11. Time savings
12. Making better use of data resources

Not all of these 12 benefits can be applied to the design tool in this research, however the proposed tool does achieve a number of these points, specifically points one (alternative approaches), eight (cost savings), nine (better decisions), eleven (time savings) and twelve (Making better use of data resources). By allowing the end user to run more alternatives to the fire design, it is hoped that a better, more cost effective solution can be put forward as an alternative to the other plans a designer might submit.

1.4 Data Collection

1.5 Software Design

As the outcome of the research is a proposed methodology for a DSS system, then a brief literature review should cover the design of the software. The tool is designed to be used by fire engineers and possibly fire engineering clients, so the tool will cater to the needs of the fire engineers. The defination of tool in this research follows that given by Lockley and Sun (Lockley and Sun, 1995) which is "a computer program that is used by engineers to perform analysis of a building or its services (prior to relisation) for the purpose of making, modifying or evaluating design decisions".

As discussed in 1.3, Keen puts forward the areas a DSS should follow to allow the best use. These were that it should be flexible, easy to use, responsive and communicative. These aspects are met in the coding of the software. For example, ease of use comes down to the design of the Graphical User Interface (GUI). A well developed GUI will allow users to navigate the program intuitivly. In the design of GUI's, Shneiderman and Plaisant lay down 8 "golden rules" of interface design. These are:-

1. **Strive for consistency** - Program design should be consistent throughout, such as layout, fonts, design and where possible, user actions and terminology.
2. **Cater to universal usability** - Recognise the needs of the users and design accordingly. Different users will use the tool differently (further discussed in a paper by Udema (Uduma and Morrison, 2007) and also mentioned by Sprague in his paper setting out the framework for DSS creation

(Sprague, 1980).) which stated that different skill levels of users would use the tool differently, depending on the users level of experience in the field the tool is designed for). This means adding help for novice users and shortcut keys and faster pacing for more experienced users.

3. **Offer informative feedback** - For each user action, the software should provide feedback though the feedback should follow the scale of actions (minor feedback for minor actions, major feedback for major actions)

4. **Design dialogs to yield closure** - Sequences of actions should be organised into groups and should have a beginning, middle and end. Feedback should be given at the completion of a set of actions so the user knows the item is complete (for example, e-commerce sites show a checkout completion screen to let users know this set of actions has been completed)

5. **Prevent errors** - Design the program to prevent errors, such as only allow numbers to be entered into a field that only needs numerical data entered. If an erroneous value is entered, provide feedback to the user and let them correct it. Allow them to only have to correct the erroneous value rather than redo the entire form.

6. **Permit easy reversal of actions** - As much as possible, allow for easy reversal of errors. This allows users a sense of relief, knowing they can undo any error - this allows for exploration of unfamiliar options.

7. **Support internal locus of control** - Experienced operators desire the sense that they are in command of the interface and the interface should be designed accordingly. Surprising interface actions, tedious sequences of data entries or the inability to gather information will build dissatisfaction with the product.

8. **Reduce short term memory load** - Human short term memory means that displays should be kept simple and short. Where appropriate, online access should be provided to command-syntax, abbreviations, shortcuts and other information.

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